Art. XII.—*A Contribution to the Physical History of the Plenty River; and of Anderson's Creek, Warrandyte, Victoria.*

By J. T. JUTSON.

(Victorian Government Research Scholar).

(Plates XXXI–XXXII., and two Text Figures).

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THE PLENTY RIVER.

Description of the Valley.

This river rises in Mount Disappointment, and runs practically due south until it meets the Yarra to the west of Templestowe. Its basin was geologically surveyed by the old Geological Survey of Victoria, and the geology is accurately delineated on Quarter Sheets 3 N.E., 3 S.E., 2 N.E., 2 S.E., and 1 N.E. In its course from source to mouth, the river passes through granitic, basaltic and sedimentary silurian and tertiary rocks. In the granitic area of Mount Disappointment, the eastern and western branches are each split up into a number of small streams, which, upon reaching the silurian country, soon unite to form the two branches mentioned. Bruce's Creek, which joins the Plenty at Whittlesea from the north-west, is its largest tributary, and is, in fact, the main stream.

The character of the valley of the Plenty immediately invites investigation. In the neighbourhood of Whittlesea, the stream is sluggish, shallow and meandering. It runs through its own alluvial flood-plain (which in places is a mile wide), bounded by subdued hills; and, with its tributaries, presents all the features of a matured river system. Below the Yan Yean Reservoir the Plenty meets the newer basalt, through

which it has cut its way. After traversing this formation for about two miles, it finds its way to the junction of the basalt and the silurian, but breaks away into the latter in two places, and also cuts through the basalt a similar number of times. Apart from these deviations, however, it keeps to the junction mentioned to Morang; then is bounded in different parts by older and newer basalt, and tertiary and silurian sediments (the silurian predominating), until it reaches the Yarra. From the time the river enters the newer basalt until it finds the junction with the silurian, its valley in the basalt does not become more than about 30 feet deep; but when it reaches the sedimentary rocks, it soon becomes a winding gorge, whose deepest part is near Morang, where it obtains a depth of close upon 250 feet from the surface of the newer basalt plain. The latter is lower than the opposite or eastern ridge of older rocks; so that from this side the depth would be greater. Here the valley is markedly V-shaped in cross section and is of rugged beauty. Its sides are steep and densely clothed with timber, and the newer basalt outcrops in large boulders, mainly on the right bank, at the top of the valley; while some splendid silurian sections are displayed on each side. In cross profile, the spurs show the steep short cliff of the basalt, and the longer, more gentle slope of the silurian beneath. After the newer basalt is left behind, the outlines of the valley become softened, as at Greensborough, but the youthful character of the stream is most obvious. A noticeable feature is the absence, south of Morang, of all but the most insignificant tributaries. At South Yan Yean and Morang, the newer basalt partly fills a large old valley, which is comparatively contracted at Morang, with high bounding ridges, but is wide and open at South Yan Yean, with lower ridges forming its sides.

Previous Literature and Remarks Thereon.

The only previous references to the physical history of the Plenty valley appear to be by Mr. T. S. Hart, M.A., and Prof. Gregory. Mr. Hart, in his interesting and suggestive paper, "The Volcanic Rocks of the Melbourne District,"[1] referring to

1 Victorian Naturalist (1894), vol. xi., pp. 74-78.

the flow of the newer basalt, states that "the lava streams extend to the east into the Plenty valley; thence southward down a narrow valley in the silurian rocks west of the present Plenty River, joining the man basaltic area south of Morang. . . . The width of the old valleys here seems quite out of proportion to the streams which flow down them; the Plenty River old valley is represented by a strip of basalt scarcely a mile wide, while on the other side of the Morang Hills the Darebin and Merri occupy a basaltic plain seven miles wide. The Plenty and all its tributaries that meet the basalt show extensive alluvial deposits above it, as if their flow had been checked: and it seems probable that all these tributaries formerly passed to the west of the Morang Hills, and perhaps the Plenty itself turned in the same direction."[1]

The hills referred to by Mr. Hart as the Morang Hills form the elevated silurian inlier with granite intrusions, shown on Quarter Sheet 2 N.E. Mr. Hart recognises the effect of the basaltic flow in largely blotting out the old valley, and in the formation of extensive alluvial deposits farther up stream, but his opinion as to the old course of the Plenty is not clear. His reference to the old Plenty valley, represented by a strip of basalt scarcely a mile wide, would fix the valley between the Morang Hills on the west, and the silurian rocks to the east of the present stream on the east; but he also thought it probable that all the tributaries of the Plenty formerly passed to the west of the Morang Hills, and that perhaps the Plenty itself turned in the same direction. In dealing with such a wide area as is covered in his paper, Mr. Hart's remarks as to the Plenty were necessarily condensed. From a recent correspondence with him I gather that he inclined to the opinion that the Plenty at the time of the newer basalt flow ran north-west of the Morang Hills, a course which he considers would be explicable as a result of capture of an old south-flowing stream by a tributary of the Merri, though at the time he did not deal with this earlier history of the Plenty.

Prof. Gregory in his Geography of Victoria (1903) states[2] that the Plenty flows south through a broad mature valley,

1 Ib., p. 77.
2 p. 112.

changing near Melbourne (? Morang) to a deep gorge, which has all the characters of a young valley. The change, he remarks, is due to the fact that the old valley has been filled up by a flood of lava (i.e., the newer basalt), that the river has had to cut its channel anew, and that, owing to the hardness of the basalt, the river has corroded its bed along the junction between the basalt and the softer silurian sandstones and shales. Prof. Gregory also maintains[1] that the King Parrot Creek and the Plenty River were probably originally one consequent river. This question is outside the scope of the present paper, and is not therefore discussed.

The remarks of both Prof. Gregory and Mr. Hart throw light on the history of the Plenty. They do not furnish a complete explanation of how the present conditions arose; but it must be remembered that they were only dealing in a general way with the subject. Mr. Hart recognises possible changes in the course of the upper Plenty; while Prof. Gregory notes that the old valley (along the present course) has had a stream of lava poured into it, and that the river has had to re-excavate between the basalt and the silurian. He also remarks on the broad mature valley up stream, and the youthful valley lower down; but he does not suggest any change in the actual course of the river.

The Later History of the Plenty.

An examination of the nature and relative position of the various geological formations along the course of the Plenty is necessary, in order to appreciate its later history. As already mentioned, at Whittlesea and Yan Yean the river meanders through an alluvial flood-plain of about a mile in width, until it meets the newer basalt. This broad alluvial plain (together with the widening of the upper tributaries) has no doubt been caused in part by the hard basalt damming the stream; or at least so retarding vertical erosion that lateral erosion took place, and built up the flood-plain. That the upper part of the valley, however, was, prior to the flow of the basalt, considerably developed, is indicated by the width of the old valley

1 Ib., p. 113.

near South Yan Yean. Looking from the elevated ridge which forms the eastern side of this valley, at a point about a mile south of Doreen, and just to the east of the road running from Doreen to the main Diamond Creek Road, a great low-lying valley, whose western side is over three miles away, is seen. Newer basalt (through which the present Plenty is cutting) occupies the floor of this valley, and has passed up some of the eastern tributaries.

It is evident, therefore, that the valley existing when the newer basalt was erupted was a wide, well-matured one. Lower down, near Morang, this old valley narrows, but still is moderately developed, as the distance from crest to crest of the bounding ridges (probably just under 2 miles) shows. These ridges are higher than their continuation northward, and this is perhaps due to the rocks to the north being softer and having suffered more denudation. The western ridge at Morang consists of granite[1] intrusive into the silurian, which has been hardened and indurated. The hardness of the rocks forming the eastern ridge is not so obvious; but many sections in the Plenty show thick beds of sandstone, which evidently has considerable resisting power here. The height of the western ridge at Morang is also explained—as noticed below—by the probability that its top formed a monadnock on the peneplain, out of which the old valley was carved. South of Morang, the old valley apparently ran to the south-west. This old valley appears to have been that of the original Plenty (i.e., the stream formed on the uplift of the peneplain); but whether, in view of Mr. Hart's suggestion, it remained so until the eruption of the newer basalt, is not certain.

The determination of this point is not, however, material, for the main purpose of this paper; but it might be observed in passing that the gap in the western ridge near Yan Yean, where Barber's Creek now enters (which is the point where the old Plenty would turn to the west if captured by a tributary of the old Merri Creek) could be made by a tributary of the old Plenty, just as well as by the backward (eastward) erosion of this old tributary of the Merri Creek. This gap has a parallel on the eastern side of the Plenty, where the tributary streams,

1 The term "granite" (which is that used on the maps of the district by the old Geological Survey of Victoria) is here used as a broad field-name only.

which now run into the Yan Yean Reservoir, had their outlet. It will be noticed that in this locality the Plenty has a narrow north and south ridge on each side of it, and that on the opposite side of each ridge a stream runs parallel to the Plenty. The eastern stream runs into the Reservoir, and the western one turns towards the south-east to join the Plenty, which (judged by the line of outcrop of the silurian on its north-eastern side), it apparently did prior to the basalt flow.

A point in favour of the capture is the continuous basalt north of the Morang Hills, from the Plenty for several miles to the west, which might indicate an old valley and a swing round to the west of the old stream. But when it is remembered that whole ridges of low elevation must have been buried by the basalt, such a ridge, separating the tributaries of the old Plenty River and Merri Creek, may have existed here. If capture had taken place before the basalt was erupted, then part of the old Plenty south of the point of capture would be turned northward, and a low ridge separating such northward flow from the stream below might lie buried near Morang. So far as I am aware, nothing is known of the thickness of the basal in the main part of the valley at Morang, and farther north; so that this point cannot be proved or disproved at present. In addition the development of the old valley between Morang and the point of capture could not be accounted for (this northward stream being too short for such work), unless it be assumed that such development took place wholly before capture.

Without further consideration of the possible changes in the old Plenty, it is clear that when the newer basalt was poured out, a valley existed to the east of the Morang Hills, down which this basalt flowed; and meeting the flow from the west, spread out south of the Morang Hills into a broad sheet stretching to the west for several miles, and also to the south, partly filling the old valleys now occupied by the Darebin and Merri Creeks. The country to the east of this main sheet of newer basalt is more elevated than the latter (except between Janefield and Morang, where the different formations are on much the same level). This elevated country consists of older basalt, silurian, sandstones and shales, and tertiary grits and gravels, and its western boundary is really a continuation of the eastern side of the old Plenty valley

above Morang. It formed an almost complete barrier to the eastward spread of the newer basalt.

This barrier was penetrated between Morang and Janefield by two narrow tongues of basalt from the main mass, as shown on Quarter Sheet 2 S.E. These tongues give the key to the later history of the Plenty River. The accurate mapping of the district by Aplin suggested to me, before going over the ground, the solution of the problem. Both these tongues have a slope south-easterly into a pre-existing valley, which now forms the lower Plenty valley. From the main road to Whittlesea, at an elevation above sea level of about 500 feet, the southern tongue descends rapidly into the present valley. At its margin, close to the stream, its upper surface is about 170 feet below the main road level. This is not due to denudation, but represents with approximate truth the fall of the basalt flow. The softer silurian and tertiary rocks on each side of this tongue slope from the main road towards the Plenty at about the same angle as the basalt. These rocks are even now mostly higher than the basalt tongue, a fact which proves that the latter partly filled on old tributary valley of the stream which is now the Plenty.

The northern tongue shows similar features, but not so pronouncedly as the other, and it has apparently been more denuded; but still it is clear that it ran south-easterly down a small valley. (See Fig. 1, which is a diagrammatic section across the upper part of this tongue in Section VI., Parish of Morang.) The southern tongue is continued as a narrow strip not more than 30 feet in thickness down the right bank of the present Plenty valley, and getting deeper into such valley, until it ceases about a mile to the north of Greensborough. It no doubt extended farther than now mapped; but was becoming thinner, and part has been removed by denudation. Its upper surface is very even, and it undoubtedly represents the approximately original surface of the flow. This strip is now broken into sections by the short but steep gullies joining the Plenty from the west. The northern tongue was probably at one time continuous with the southern one; but river action has disconnected them.

At the end of the northern tongue of basalt, the lower surface of the latter is about 170 feet above the Plenty, and at the end of the

southern tongue about 100 feet above the same river. Where the Maroondah Aqueduct crosses the present Plenty (which is near the end of the narrow strip of basalt above mentioned) the lower surface of the basalt is about 60 feet above the stream and about 125 feet below the immediate top of the valley. (See Fig. 2, which is a diagrammatic section at the Maroondah Aqueduct.) From these measurements, and allowing also for the rise in the bed of the present Plenty, it can be seen that there is a rapid fall in the lower surface of the basalt between the northern tongue and the Maroondah Aqueduct. Where the valley rises above the level of the basalt flow, it is even now fairly undeveloped, especially towards the end of the narrow basaltic strip. It is clear, therefore, that the present Plenty valley from Morang southward existed before the flow of the newer basalt, as a young valley with a rapid fall. Since the lava stream, this valley has been re-excavated between the basalt and the other rocks, but to a much greater depth, and with an accentuation down to its mouth of its youthful character.

The conclusion is therefore reached that before the flow of the newer basalt, there existed a broad, moderately mature valley above Morang, and one indicative of youth below, which reverses the normal order, if it be assumed that these two valleys were then continuous. No satisfactory explanation can be given for this unusual deviation. If, however, the upper and lower valleys be regarded as originally distinct, then the observed facts become explicable; and the probable sequence of events may thus be stated. Before the flow of the newer basalt, the Plenty as a mature stream ran in a south-westerly direction from Morang,[1] having as the eastern side of its valley the more elevated land now forming the eastern border of the main basalt flow, as before noted. The present lower Plenty formed an independent stream, young and vigorous, with a steep grade and running in a south-easterly direction. It had eaten its way back towards the old Plenty valley, near Morang, and probably in time would have captured the head waters of the stream there.

1 If capture had taken place at the Barber's Creek Gap the streams would be altered, but the old valley at Morang remained. Such capture would not affect the present argument.

The head of this independent stream was probably forked, the prongs representing the small valleys occupied by the two tongues of newer basalt already mentioned. These small valleys had notched the ridge forming the eastern side of the old Plenty valley, the ridge itself probably being reduced by the proximity of two valleys, as commonly occurs. The newer basalt flowing down the old Plenty valley above Morang was, in comparison to the flow to the westward, south of the Morang Hills, cramped for room. It would thus tend to increase in height and bank itself against the bounding ridges. Tracing the eastern edge of the basalt northerly from about 1½ miles north of Bundoora to the head of the southern tongue of basalt, the country rises very rapidly. This is shown also by the heights recorded on Quarter Sheet 2 S.E. along the Yan Yean Reservoir Pipe Track, where a rise of 100 feet occurs in about a mile (340 feet to 440 feet). At South Morang Railway Station (about 2 miles from the 440 feet level), the height is 512 feet (a rise of 72 feet). Between here and South Yan Yean (3 miles) there is only an increase of 20 feet. The easterly tributaries of the old Plenty provided more room here.

Possibly the greatest check to the flow would be just to the south of Morang, where the basalt coming down the old Plenty valley would meet the main mass from the western side of the Morang Hills; and it is precisely at this point (as the heights above given show) that the greatest amount of ridging up has taken place. This ridging up was sufficiently high to enable the basalt to overflow at the two notches mentioned above, and to run down as two narrow tongues into the present lower valley of the Plenty: and thence continue as the narrow strip down such valley. After the basalt flow, the upper Plenty found its way and kept mainly to the junction of the basalt and the older rocks, and so worked its way down as far as Morang.

If the two tongues of basalt had not existed, in all probability the course of the river would have continued in a south-westerly direction, between the junction of the main basaltic mass and the older rocks to the east, and would have eventually entered the present Darebin Creek valley below

Bundoora, emptying itself into the Yarra, where that creek now enters. The lateral overflow of the basalt changed this. The stream naturally kept between the basalt and the silurian, and so entered the younger valley. Once there it retained its course, keeping the thin basaltic strip to the west, and excavating much more deeply than the level of the basalt. Hence the diversion of the upper Plenty waters through the Greensborough country to the Yarra to the west of Templestowe.

The fall of the narrow strip of basalt in the old independent stream has already been noticed. It is interesting to record the fall of the present river in various parts. Between Greensborough (river bed about 100 feet above sea-level) and the southern tongue of basalt already referred to (river bed about 200 feet above sea-level), a distance of over 3 miles, the fall would be about 30 feet per mile. Between this southern tongue and South Yan Yean (river bed about 500 feet above sea-level) a distance of about 5 miles, the fall would average about 60 feet per mile.[1] If a mile to the south of South Yan Yean be left out of the calculation, the fall would be greater, as the stream in this mile runs entirely through basalt and its valley is shallow (not more than 30 feet deep). When the basalt has been cut through and the softer silurian rocks met, erosion acts much more rapidly. About South Yan Yean the river continues in a very shallow valley, whose fall would approximate to that of the country through which it runs. Thus between South Yan Yean (532 feet) and Whittlesea (637 feet) a distance of about 6 miles, the difference in height is 105 feet, giving an average per mile of 17½ feet.

The figures quoted bring out two points very clearly. Firstly, the gentle grade of the valley, cut in a pre-existing one, as compared with the steep grade (once the basalt is cut through), where the river had to cut entirely afresh. This is what would be expected. Secondly, the wonderful power of resistance to denudation of the basalt, compared with the silurian sediments (although these in places are fairly hard rocks). Where the stream has not cut through the basalt into the underlying rocks, the valley is shallow and insignificant, but where such cutting has been done a deep gorge exists.

1 Except the heights of railway stations and those mentioned on the Quarter Sheets those given in this part of the paper have been determined by aneroid.

The Probable Old Course of the Plenty.

It has already been remarked that, in the writer's opinion, the old course of the Plenty (now occupied by newer basalt) was originally to the east of the Morang Hills as far south as Morang, and then probably to the south-west. What the actual course was below Morang before the flow of the newer basalt can only be surmised. The lava has covered such a wide stretch of country to the west that the ridges and valleys have alike been covered up. That such ridges and valleys did exist is proved by the remnants of the ridges and valleys to the north and south of the main basaltic area. From the character of the exposed ridges and valleys, the covered ridges were probably broad, and the valleys comparatively narrow. The southern ends of the ridges, as at Preston and Essendon, are exposed, apparently, on account of the basalt thinning out in its flow southward. The northern outcrops, such as the Morang Hills (granite and indurated silurian), some isolated hills at Donnybrook (indurated silurian) and the hills at Broadmeadows (mainly granite) may be accounted for by the hardness of the rocks. They are probably residuals or monadnocks in the formation of the peneplain, out of which the old pre-newer-basaltic valleys have been carved.

Assuming that the old Plenty came down the Morang valley its most probable lower course would be either to the west of Preston down the old valley of the present Merri Creek, or down the old valley of the present lower Darebin Creek. The latter appears to be the more likely. If the Plenty ran south-westerly from Morang towards the Merri Creek valley, the old Darebin Creek valley would necessarily be short, but so broad that it would be out of proportion to its length. Moreover, the main mass of the newer basalt is bounded by a ridge from Morang to south of Bundoora, which suggests that such ridge formed the continuous eastern boundary of an old stream. For these reasons, the Darebin Creek valley is adopted as the original course of the Plenty. It may be noticed that the valley is narrow where the main road to Whittlesea crosses the Darebin Creek; but some very hard tertiary quartzites occur on the

eastern side, which will account for its contraction. This repeats a feature already noticed in the old valley at Morang, due to the hard granite and indurated silurian.

If the original Plenty followed the course suggested, its western side was probably a low ridge connected with the Morang Hills, and the ridge of silurian and tertiary strata at Preston. This assumed part of the ridge is covered by newer basalt; and the question arises why such middle part should be covered and the ends exposed. The southern end is bare, probably on account of the basalt thinning out in its southward flow. A point would be reached where the valleys alone could receive the whole of the basaltic stream. As regards the Morang Hills, reference has already been made to the possibility of their upper portion forming a monadnock on the old peneplain. These hills towards their centre (where the granite and indurated silurian rocks occur) have a fairly even sky-line. To the north and south, this line drops rather suddenly, and in the south it quickly passes under the basalt. To the north, after the rapid drop, the lower part runs northerly as an even ridge of about the same height, or in the same line of slope, as the western ridge of the Plenty between Whittlesea and Yan Yean, with which it was at one time continuous. It is now broken by the Barber's Creek Gap. The height of this ridge near South Yan Yean (in section 2, Parish of Yan Yean) is about 700 feet above sea level. The top of the Morang Hills is probably at least 100 feet higher. If the 700 feet ridge be continued in a sloping line southward, it would meet at the southern end of the hills, the lower ridge which soon passes beneath the basalt. Thus if the upper part of the Morang Hills be treated as a monadnock, the discrepancy between their height and that of the assumed covered ridge to the south is somewhat explained. In any event, however, the hard rocks would ultimately tend to project above the surrounding softer ones. When it is remembered that the newer basalt was high enough to pierce the ridge forming the eastern boundary of the main basaltic mass, and that this ridge is protected by caps of older basalt, it is not difficult to believe that a ridge lies buried between the Morang Hills and Preston, especially if that ridge did not possess any hard rocks as a protection against denudation.

If the Plenty were captured at the Barber's Creek Gap before the flow of the newer basalt, its upper waters would be diverted into the old Merri Creek basin, but the original valley southwest of Morang would remain, carrying an independent stream until the newer basalt eruptions.

The Relations of the Plenty and Yarra Rivers.

The old Plenty gives evidence of having been fairly well developed before the flow of the newer basalt; and from the width of the old Merri Creek valley, the same may be said of that. (From the geological maps, it seems probable that the old Merri Creek was joined by the old Moonee Ponds Creek). The Yarra for some distance above Templestowe has all the characters of a youthful valley, as Prof. Gregory has pointed out.[1] Between Templestowe and the mouth of the Darebin Creek, the river meanders through its own alluvium. Dr. Hall[2] has remarked that the newer basalt (down the Darebin Creek valley) checked the flow of the river above the Fairfield railway bridge, the effect of which was to build up a plain of sediment up the Yarra as far as Templestowe, and up the Plenty, where, a mile above its junction with the Yarra, the alluvium is 30 feet deep. The checking of this body of water would also cause the river to meander and so to widen its valley. It has similarly affected the Koonung Koonung Creek, although this is not shown on the geological maps. The effect of the basalt bar at Fairfield extends to the Plenty, and up that stream to some extent. As mentioned above, the upper Plenty waters were diverted at Morang by the newer basalt flow into the present Plenty channel. Hence practically at the same time the Yarra was checked at Fairfield, and a large additional volume of water from the upper Plenty basin was poured into the Yarra through the present Plenty mouth. This water, without the bar at Fairfield, would tend to widen the stream below its entry (if the stream were at or near its grade), and tend to a somewhat sharp disparity between the nature of the valley above and below the mouth of the present Plenty. It would be accentuated by the basalt at Fairfield, and in this way the existing conditions have arisen. The limitation of the alluvial flats up

1 Ib., pp. 106 and 107.

2 Victorian Hill and Dale (1909), p. 42.

stream, the wide mouth of the Plenty valley and the extension of the alluvium up that valley, are partly explained by the diversion of the Plenty waters from above Morang.

From these circumstances it may be inferred that the Yarra valley was, at the time of the newer basalt flow, as far as its junction with the old Plenty valley (the Darebin Creek valley) similar to that now above Templestowe, and hence a young valley. The old Plenty[1] and the old Merri Creek were, judged by their valleys, apparently more developed than the Yarra. The latter stream probably joined the old Plenty near Fairfield, which in turn would join the old Merri Creek at Clifton Hill. The combined streams would then flow down the valley of Collingwood and Richmond (now occupied by the newer basalt) to Melbourne. At this time the Yarra could not, perhaps, from its stage of development, be regarded as the main stream. With the diversion of the upper Plenty waters, however, consequent on the eruptions of the newer basalt, the old Plenty valley received only the small Darebin Creek; but even this was turned into the Yarra above the basalt. The Yarra also received the whole of the water from the present Plenty basin. It thus gained increased erosive power, which enabled it to cut its channel below Fairfield much faster than its only rival, the present Merri Creek (the drainage area of which, since the flow of the newer basalt, is much less than formerly, if, as suggested above, the old Moonee Ponds Creek once joined it); and so the Yarra became the predominant stream.

Summary.

The Plenty River originally passed down the Morang valley, and from Morang probably ran south-westerly and southerly into what is now the Darebin Creek valley. This old Plenty valley was fairly well developed before the newer basalt flow.

The possibility of changes in the course of this stream before the eruption of the newer basalt is indicated.

The present Plenty below Morang was originally an independent young stream, with its heads near Morang, and with a steeper fall than at present.

1 The stream referred to here and shown as an old river on the accompanying map is what is mentioned above as the original Plenty. If capture had taken place at the Barber's Creek Gap, of course the remaining stream down the lower part of the original Plenty valley would be much reduced.

The newer basalt obliterated most of the old Plenty, and overflowed the heads of the independent valley by two small tongues of basalt. By means of these tongues, the upper Plenty waters were diverted to the south-east into the independent valley, which has since been more deeply cut into. The old valley above Morang has been deeply re-excavated.

The newer basalt covered some of the ridges as well as the valleys, and so largely obliterated traces of the old streams; but despite this, the basalt flows are invaluable for tracking these earlier streams.

The striking difference in the power of resistance to erosion between the newer basalt and the silurian sediments, is indicated by a comparison of the grades of the present Plenty above and below the point where the stream has cut through the basalt into the silurian.

The effect on hard rocks is also shown at Morang, where, through the delay in cutting through such rocks, the old stream formed a wide open valley above.

The tops of the Morang Hills and of other high points are suggested as monadnocks on the peneplain out of which the Plenty was originally carved.

The diversion of the upper Plenty waters at Morang in consequence of the newer basalt flow, has accentuated the lateral erosion of the Yarra between Fairfield and Templestowe.

The Yarra was probably less developed prior to the newer basalt eruptions than the old Plenty River and Merri Creek, and perhaps, judged from that standpoint, could not be regarded as the main stream; but since then it has become the predominant river.

ANDERSON'S CREEK, WARRANDYTE.

From almost any of the higher view-points at Warrandyte, the tops of the hills and ridges can be seen stretching away in so even a line that there can be no doubt that they are the remnants of an old peneplain, the highest points of which (in the immediate neighbourhood of Warrandyte) are probably about 450 feet[1] above sea-level. This peneplain has, since its

1 All the heights mentioned in this part of the paper are based on aneroid readings.

uplift, been deeply but not maturely dissected. Vertical erosion has been extremely active; but lateral erosion has not progressed very far. The country, therefore, is broken into a series of narrow and steep valleys and sharp ridges. The principal stream is the Yarra, which is here confined to a narrow valley. The township of Warrandyte lies on the southern side of the river; and at its western end, Anderson's Creek enters the Yarra from the south, while at the eastern end, Parson's Gully joins the same main river. It is with the relations between Anderson's Creek and Parson's Gully that this paper is concerned; and therefore some remarks on the directions and positions of these valleys will be offered.

Anderson's Creek rises a little to the north of Ringwood. It consists here of two small creeks, which soon unite; and the resulting stream then runs in a direction a little west of north until it approaches the western head of Parson's Gully, when it turns more to the west, and so continues until joined by Harris's Gully from the south. It then runs northerly to the Yarra. Although Anderson's Creek along its whole course is essentially a young stream, this feature is more marked in that portion between the turn near Parson's Gully and its junction with Harris's Gully. The part mentioned is a deep gorge, and contrasts with the other more open divisions of the valley. The best view, perhaps, of the gorge (which it is convenient to refer to as the "Anderson's Creek Gorge") is from the southern end of Fourth Hill, where it is about 300 feet in depth.

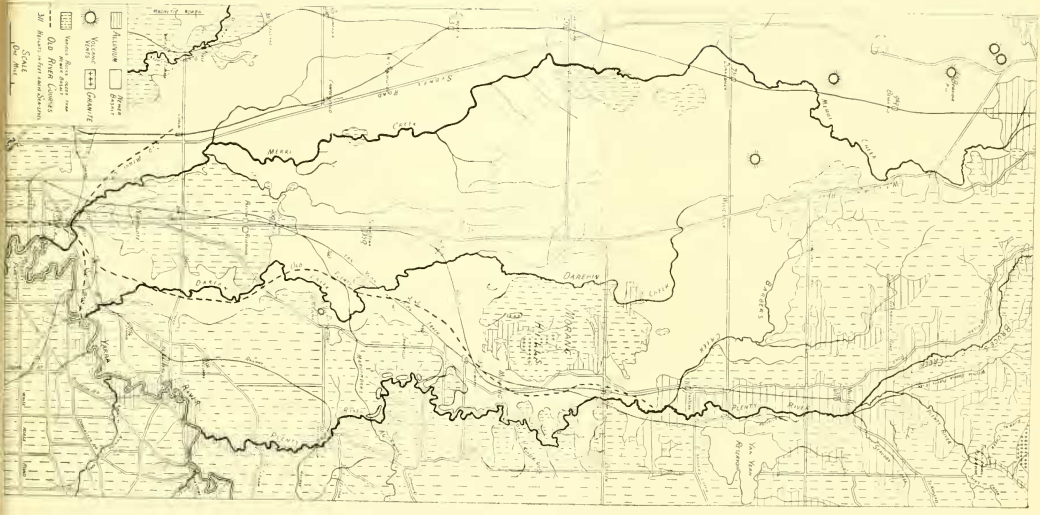
Parson's Gully is less in length than Anderson's Creek, as the accompanying map indicates. Its head is forked, the eastern prong of the fork being nearly a mile, while the western one is about a quarter of a mile in length. The western prong is close to the entrance to the Anderson's Creek Gorge. Parson's Gully is a fairly broad, open valley, different from Anderson's Creek Gorge, but resembling in general characters the upper and lower parts of Anderson's Creek. The main road from Warrandyte to Ringwood runs through the valley of Parson's Gully as far as its western head, when it crosses into the valley of the upper Anderson's Creek. Harris's Gully is similar in character to Parson's Gully, but not so broad and well developed, although of greater length. All the valleys mentioned are deeply trenched in the peneplain.

The Warrandyte goldfield is mainly confined to the area of country bounded by the Yarra River, Anderson's Creek and Parson's Gully. (Reefs extend beyond these boundaries, but are not too plentiful.) The cause of this I hope to explain in a later paper. For the present, it will suffice to note the fact. The rocks of this area are of silurian age, and consist in part of coarse sandstones, grits and conglomerates. Quartz in the form of reefs and veins, filling joints and others fissures, is widespread and abundant. By its injection the rocks have become hardened and more resistant to denudation. The conglomerates, grits and coarse sandstones, and, apparently, also the quartz reefs, gradually die out south of the Anderson's Creek Gorge; but the latter is not the actual boundary of the reefs or of the hard rocks. This is well shown by the Great Southern Hill, which forms the continuation of the ridge known as Fourth Hill on the northern side of the gorge. This ridge forms the crest of an anticline, and the effect of the hard rocks of the Great Southern Hill is well illustrated in the small gully known as Beauty's Gully, which runs eastward from its mouth in an almost level line till it meets the ridge, when it sharply rises. To the south of Beauty's Gully other easterly tributary gullies of Harris's Gully extend much farther to the east, on account, no doubt, of the rocks there being softer.

To the east and west of Parson's and Harris's Gullies respectively, the conglomerates, grits and thick sandstones together with the quartz reefs, practically disappear. The rocks consist mainly of shales, and are therefore softer and liable to more rapid denudation than the coarser-grained silicified rocks of the Warrandyte goldfield area. Here again the effect of the hard rocks may be seen in Parson's Gully. On its western side the tributary gullies are short and steep, whilst on the eastern side they are long and well graded. The strike of the silurian rocks of the district is a few degrees to the east of north. The directions of Parson's Gully, Harris's Gully, and the upper and lower Anderson's Creek approximate towards the strike of the rocks, while Anderson's Creek Gorge cuts across both the strike and some of the hardest rocks. Parson's Gully and the upper part of Anderson's Creek on the eastern side, and Harris's Gully and the lower part of Ander-

son's Creek on the western side of the goldfield area, run approximately parallel to one another. Fifth Hill, a high point on the old peneplain at the entrance of Anderson's Creek Gorge, is about 270 feet above the bed of the stream. The western head of Parson's Gully is separated from the gorge by a low ridge, the latter being about 170 feet below the top of Fifth Hill, and is therefore about 100 feet above the bed of the Anderson's Creek Gorge. This ridge is continued as a shelf in Anderson's Creek valley, above the gorge, and also in Parson's Gully, on the eastern side of the latter valley. In this shelf Anderson's Creek has cut a narrow, steep valley; and Parson's Gully and its tributaries have also somewhat dissected it. The connecting low ridge itself has practically not been cut into.

All these facts seem to point to the following conclusions:— At the uplift of the peneplain, the natural drainage lines would appear to have been along Harris's Gully and its continuation (the lower part of Anderson's Creek), on the western side; and the upper part of Anderson's Creek and its continuation (the present Parson's Gully) on the eastern side. The harder ground between would be avoided as far as possible. The two streams would be independent of one another. Tributaries on each side of both streams would, of course, be formed as the main streams eroded their channels. One of such tributaries of Harris's Gully apparently flowed westerly from the divide between the two main streams along the course now occupied by the lower part of the Anderson's Creek Gorge. This tributary would have difficulty in cutting through the hard rocks of the goldfield, but its grade would be steep, and this, aided by some faulting which has probably taken place along part of the line of its valley, would cause rapid vertical erosion and form a deep gorge. Gradually eating its way backward, this tributary appears to have eventually reached the eastern main stream, and to have captured its upper waters when the valley of this eastern main stream was not lower than the reduced ridge previously referred to close to the Ringwood Road. By this capture, the tributary became the main stream of the district, the present Anderson's Creek. Harris's Gully, which was formerly the main western valley, became subordinate to the tributary, and the old eastern stream was reduced to the present Parson's Gully, occupying


Old River Courses
Alluvium
Granite
Scale
Merri Creek
Darebin
Yarra River